Improvement of Aerosol Prediction Capability

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LONG-TERM GOALS

This work unit is part of a coupled 6.2-6.4 development effort to implement rapid transition of aerosol prediction and EO tactical decision aid capability to the Fleet and is carried out by NRL-Montery and SPAWAR-SSC. The coupled program will improve the components of the Target Acquisition Weather Software (TAWS) and couple operational EO tactical decision aids (TDA's) to numerical weather prediction and aerosol models. Specific elements of this approach (and the responsible person) include: A: Develop and validate operational, diagnostic, and prognostic versions of the Navy Aerosol Analysis and Prediction System (NAAPS) for analysis of airborne dust loads (Westphal/NRL). B: Modify existing radiative transfer codes to ingest NAAPS forecasts. Produce practical products that depict the state of the atmosphere in terms of visibility and range (Reid/SSC; Tsay/GSFC; Westphal/NRL). C: Improve the current marine target radiance models by developing new surface wake models and adding improved ship target models that include wake production (Doss-Hammel/SSC). D: Develop and improve operation of TAWS in maritime scenarios by utilizing numerical weather analyses and forecasts and surface and satellite observations (Goroch/NRL).

This work unit addresses parts A and B. The work unit goals are to address EOTDA and operational needs using a predictive, global, operational aerosol model and radiative transfer model to produce global and regional forecasted fields of key radiative and visibility parameters in real time for use in weather forecasting and operational planning.

OBJECTIVES

The objective of this work unit is to transition NAAPS and related radiative transfer codes to Milestone I. This includes validation and documentation of the models and development of a suite of products.

APPROACH

An existing global aerosol model (NAAPS) will be transitioned to Milestone I according to the conventional procedures. This includes porting the model to the NRL O2K, converting it to Open-MP, making the input-output compatible with FNMOC standards, writing documentation, conducting global and regional validation, developing a suite of useful products, and documenting the resource requirements.   The product line will be developed with input from the users. It will include global and regional fields of radiative fluxes, optical depth, and visibility from aerosol fields as well as real-time and post-time metrics suitable for validation of NAAPS. The validation process will also include

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14. ABSTRACT

This work unit is part of a coupled 6.2-6.4 development effort to implement rapid transition of aerosol prediction and EO tactical decision aid capability to the Fleet and is carried out by NRL-Montery and SPAWAR-SSC. The coupled program will improve the components of the Target Acquisition Weather Software (TAWS) and couple operational EO tactical decision aids (TDA's) to numerical weather prediction and aerosol models. Specific elements of this approach (and the responsible person) include: A: Develop and validate operational, diagnostic, and prognostic versions of the Navy Aerosol Analysis and Prediction System (NAAPS) for analysis of airborne dust loads (Westphal/NRL). B: Modify existing radiative transfer codes to ingest NAAPS forecasts. Produce practical products that depict the state of the atmosphere in terms of visibility and range (Reid/SSC; Tsay/GSFC; Westphal/NRL). C: Improve the current marine target radiance models by developing new surface wake models and adding improved ship target models that include wake production (Doss-Hammel/SSC). D: Develop and improve operation of TAWS in maritime scenarios by utilizing numerical weather analyses and forecasts and surface and satellite observations (Goroch/NRL).

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comparisons with TAWS transmission calculations. For this, J. Reid (SPAWAR-SSC) and S. Tsay (NASA/GSFC) will develop a fast method for calculating the bulk radiative fields for NAAPS fields. Reid will develop new parameterizations for the optical properties of the NAAPS aerosol components (dust, smoke, and sulfate) for use in the RT code of Tsay.

WORK COMPLETED

The Electro-Optical Prediction RTP project began this year. We are presently working on the FY01 tasks which include 1) Begin implementation of an operational, diagnostic version of NAAPS and development of robust predictive version of NAAPS; 2) Begin development of a radiative transfer scheme to estimate radiative fluxes, optical depth, and visibility from aerosol fields generated by NAAPS. (Note that the 'diagnostic' and 'prognostic' versions of NAAPS are now nearly the same codes. Hence, only one code is mentioned in the discussion that follows.)

For task 1, we have begun moving the code from the Rossby SGI machine to the NRL O2K where we will convert it to Open-MP and make the input-output compatible with FNMOC standards. We have had discussions with FNMOC on the transition process: coding convention, documentation, validation, reporting, products, timeline, resource requirements, etc.

For task 2, J. Reid (SPAWAR-SSC) and S. Tsay (NASA/GSFC) are developing a fast method for calculating the bulk radiative fields for NAAPS fields. We have built interfaces between NOGAPS and MODTRAN (MODerate-resolution radiative TRANsfer model) to compute visibility, and between NAAPS and the Fu-Liou 4-stream radiative transfer model to derive shortwave and longwave fluxes. The interfaces are subroutines that produce the input parameter control files used by MODTRAN and the Fu-Liou radiative transfer codes. Precision tests of the radiative transfer models (MODTRAN and Fu-Liou codes) are performed in SGI computing system. Test runs by using NOGAPS outputs are performed to derive the atmospheric visibility, assuming a pre-existing aerosol model in MODTRAN. Since the output of NAAPS provides only aerosol mass concentrations, a subroutine needs to be built for incorporating aerosol physical properties (e.g., refractive index, size distribution, and vertical profile) and Mie theory for calculating aerosol extinction for use in deriving aerosol optical depth. The aerosol models are pending upon the field measurements. Currently, we are building the aerosol interface subroutine for an arbitrary aerosol model. Specifically, we have focused on two aspects, namely the computation of aerosol optical properties and the modification of the Fu-Liou code.

Optical properties of aerosols - The standard output of NOGAPS in each grid point are profiles of the following parameters: ambient temperature and moisture, aerosol mass and concentration for three aerosol species (dust, smoke and sulfates). Because NAAPS does not compute the aerosol size distribution explicitly (essential for the derivation of optical parameters such as visibility), a methodology has to be implemented in order to derive them. From literature values, three size distributions typical of each aerosol species have been selected and along with the concentrations given by NAAPS. The distributions are fed into a Mie code that computes all the parameters needed for radiative transfer computations (spectral extinction and scattering coefficients and the coefficients of the expansion of the phase function in Legendre polynomials). Then, these parameters are integrated over the spectral bands required by the Fou-Liou radiative transfer code. We continue to work on the selection of size distributions and modification of our Mie code for integration of optical properties.

Fu-Liou code (FL) - Two subroutines have been created that will add the capability of computation of aerosol radiative properties by the FL code. One is called aerosol.f and it computes the aerosol optical

depth, single scattering albedo, and asymmetry factor (g) at each layer and in band defined by the FL code. The inputs to this subroutine are the aerosol extinction and scattering coefficients and the asymmetry factor in each layer integrated over each spectral band defined by the FT code. Note that for simplicity, we are using a Henyey-Greenstein Phase function, which is not very realistic of actual aerosol phase function but it has the advantage of being very easy to implement. In later versions of the code, the actual Legendre polynomials coefficients will be incorporated. The second subroutine computes the combined single scattering properties due to Rayleigh, water droplets, ice crystals, greenhouse gases and aerosols in each layer. The two subroutines have been incorporated to the FL code and compiled with no problems. However, test runs have not been performed yet since the input routines that provide the optical properties are unfinished.

RESULTS

Prototype regional web pages that present the current NAAPS products have been developed and shown to Navy personnel in those regions (Figure 1). Their feedback has been positive and will continue to be solicited. A site visit to Rota, Spain, planned for mid-September, was cancelled and will be re-scheduled.

IMPACT/APPLICATIONS

The models and products developed through this program will have considerable impact on estimates of EO propagation, operations, and weather prediction. The current user-specified aerosol type in NAM and TAWS will eventually be replaced by the predicted values from NAAPS. The current forecast products, once they are available over SIPRNET, will aid decision-making for daily Navy activities, such as carrier operations and port entry (the latter have been delayed by dust storms in the past.) The operational aerosol products will be used for initialization or specification of aerosols in COAMPS when new cloud microphysical scheme becomes available.

TRANSITIONS

None.

RELATED PROJECTS

The NRL 6.1 Atmospheric Physics, NRL 6.2 Mesoscale Modeling of the Atmosphere and Aerosols, and ONR 6.2 Coastal Aerosol Distribution by Data Assimilation, and NRL 6.2 Physics use NAAPS products and the satellite retrievals for investigations and validation. .

SUMMARY

The Electro-Optical Prediction RTP project began this year. We are presently making significant progress towards the FY01 tasks which include 1) Begin implementation of an operational, diagnostic version of NAAPS and development of robust predictive version of NAAPS; 2) Begin development of a radiative transfer scheme to estimate radiative fluxes, optical depth, and visibility from aerosol fields generated by NAAPS.
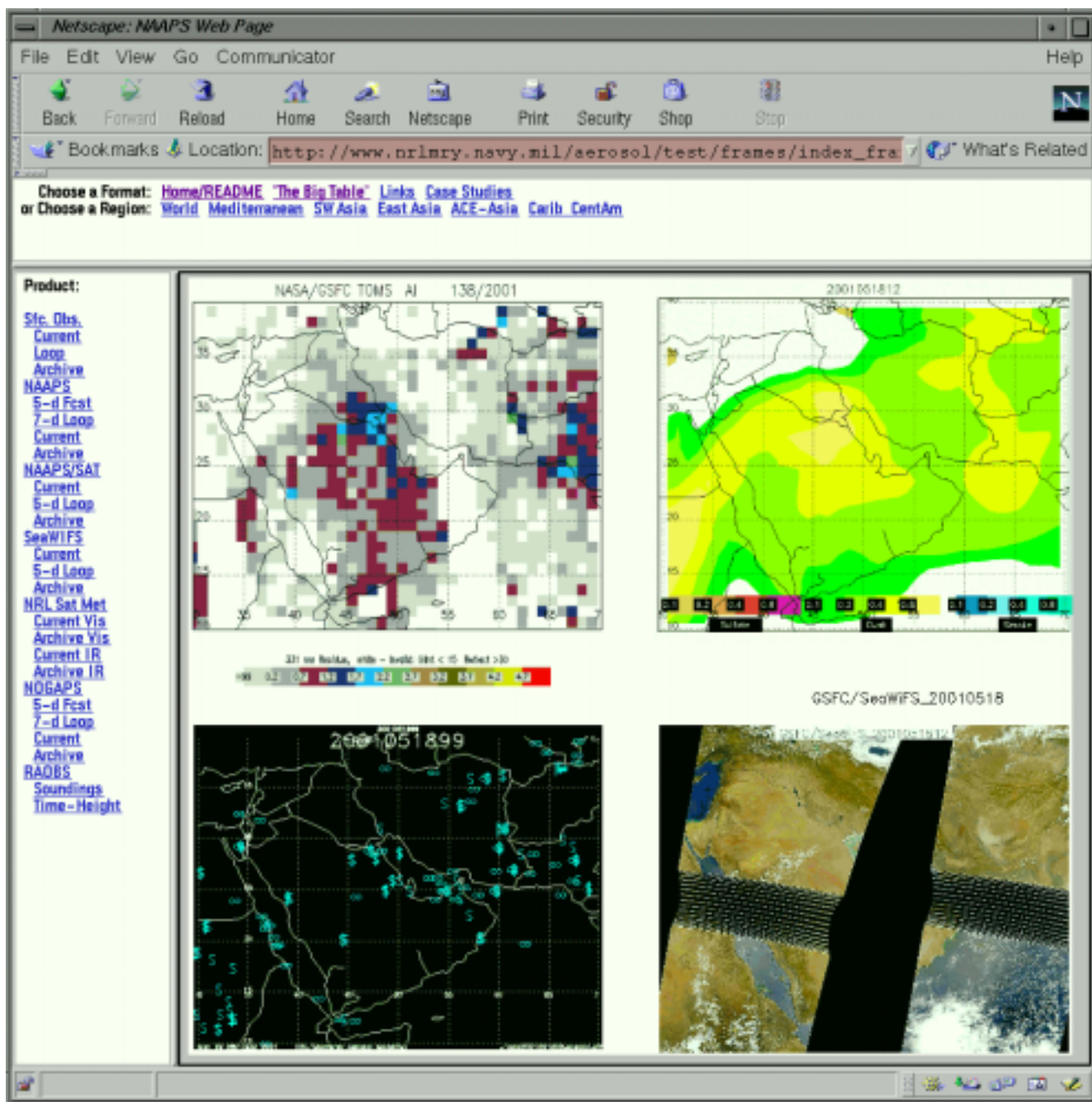
Figure 1. This is the NAAPS regional web page. Available domains are listed in the top frame, as well as reference pages. The left frame shows the products available for the current regional domain; in this case, Southwest Asia. The right frame shows the 'NAAPS/Sat' for May 18, 2001. The product compares the TOMS Aerosol Index (upper-left), NAAPS-predicted optical depth (upper-right), surface observations of aerosols (lower-left), and SeaWiFS visibile image (lower-right). (The components of the composite image are explained in detail on line by clicking on the 'NAAPS/Sat' text in the left frame.) The dust event in Afghanistan is shown in detail in Figure 2.
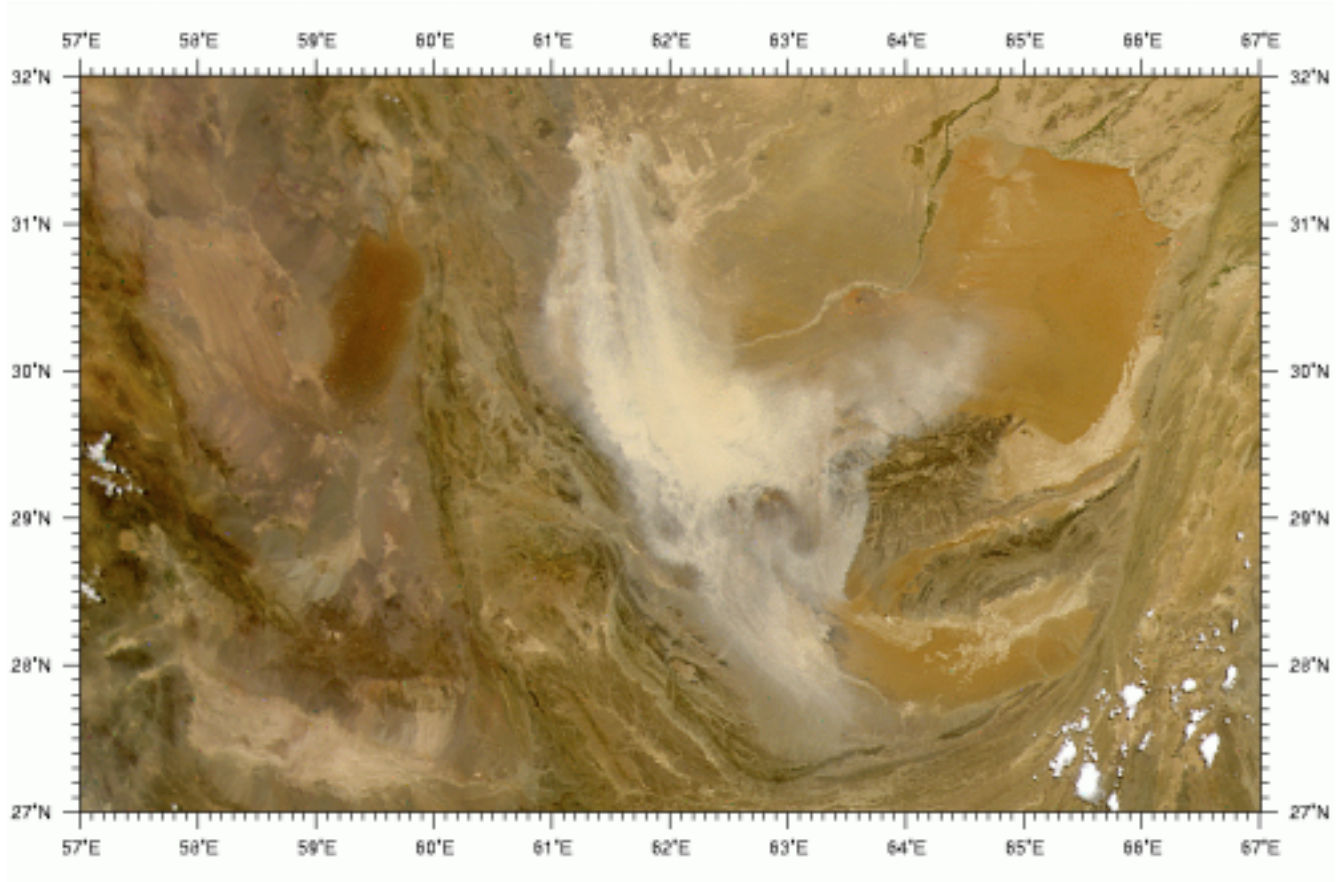
Figure 2. SeaWiFS visible imagery for May 18, 2001, showing a dust storm originating at dry lakes along the Iran-Afghanistan border and then traveling south into Pakistan. The dry lakes are normally wet, but Afghanistan now controls the river that feeds the lakes and little water is allowed through. These dust plumes often reach the Arabian Sea.

REFERENCES

None.

PUBLICATIONS

None.